



**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10**

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OFFICE OF
WATER AND
WATERSHEDS

MEMORANDUM

Draft: May 23, 2016

SUBJECT: Temperature Assessment for the Clearwater Paper Lewiston Mill Discharge through Outfall 001

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TO: Administrative Record for Clearwater Paper Lewiston Mill, Permit #ID0001163

1 Introduction

The prior NPDES permit for the Clearwater Paper Lewiston Mill, issued in 2005, included water quality-based effluent limits (WQBELs) for temperature. The basis for these limits was explained in the "Temperature Assessment for the Potlatch Mill Discharge through Outfall 001," (2005 Temperature Assessment) (Koch and Nickel 2005).

The purpose of this memorandum is to reassess the temperature WQBELs in the 2005 permit to determine if they will continue to meet applicable water quality standards and are consistent with the thermal plume recommendations in *EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards* (EPA 2003).

2 Description of Receiving Waters and Discharge

2.1 Receiving Water

Effluent from the Clearwater Paper Lewiston Mill discharges through outfall 001 to the Snake River at its confluence with the Clearwater River, near the head of Lower Granite Pool. The outfall is located at latitude 46° 25' 31" N, and longitude 117° 02' 15" W (approximately river mile 140).

The discharge location is at the nexus of three 8-digit hydrologic units. It is at the downstream ends of both the Lower Snake-Asotin watershed (17060103) and the Clearwater watershed (17060306). It is at the upstream end of the Lower Snake-Tucannon watershed (17060107).

2.1.1 Mixing Properties of the Snake and Clearwater Rivers

Mixing of the Snake and Clearwater Rivers at the confluence is complex. As described in *Hydraulic Characteristics of the Lower Snake River During Periods of Juvenile Fall Chinook Salmon Migration* (Cook et al. 2006), circulation patterns at the confluence are driven by the temperatures and discharge rates of the Snake and Clearwater Rivers, and three general patterns are observed.

When the temperatures as well as the discharge rates of the two rivers are similar, the two rivers flow parallel to each other, with little mixing occurring between the two rivers for several miles downstream from the confluence.

When there is a small difference in temperature but a large difference in discharge rates between the two rivers, the two rivers will mix together within a short distance downstream of the confluence.

When there is a large difference in temperature between the two rivers, the colder Clearwater River plunges beneath the warmer Snake River at the confluence, creating a vertically stratified temperature profile. During July and August, the Clearwater River is significantly cooler (10 degrees or more) than the Snake River, and the resulting density difference is sufficient to stratify Lower Granite Reservoir. This vertical stratification due to large temperature differences occurs over a wide range of discharge rates.

The EPA represented these varying conditions in the modeling as described in Section 6.1.2, below.

2.1.2 Natural Background Temperature

The temperature water quality standards for both Idaho and Washington include natural condition provisions, as described in Section 3, below.

Evaluation of the natural background criterion requires knowledge or estimates of the natural water temperature condition without human impacts. Both temperature observations and the temperature simulations can provide estimates of water temperature. Since there are information gaps and uncertainties associated with both the observations and the simulations, both are used to gain an understanding of the free flowing and impounded temperature regimes and the relative importance of dams, point sources and tributaries in altering the natural regime of the river.

EPA has used several methods (Cope 2004, 2005) to show that water temperatures in an undeveloped or natural Snake River would exceed Idaho's daily average temperature criterion of 19°C between 97 and 100% of the time in July, 100% of the time in August, and between 17 and 33% of the time in September. Therefore, during these months, EPA has applied the natural condition provisions of Idaho's water quality standards for temperature (IDAPA 58.01.02.200.09 and 58.01.02.401.01.c). See Section 3.1, below, for more information on Idaho's water quality standards for temperature.

2.2 Outfall 001

The effluent is released through outfall 001 from a 400-foot long diffuser. The depth of the water at the discharge point is approximately 30 feet. The diffuser is in waters of the state of Idaho and upstream of the Idaho-Washington state line by 191 meters. The diffuser consists of 80 individual ports spaced 5 feet apart rising from a common, buried 48-inch outfall pipe. Each riser pipe is angled 30 degrees from horizontal with the exit port about 1.5 feet above the river bottom. Each riser pipe is 3 inches in diameter. Only 72 of the 80 ports are currently operating.

3 Applicable Water Quality Standards

3.1 Idaho

3.1.1 Water Quality Criteria for Temperature

At the point of discharge, the Snake River is designated for cold water aquatic life (as well as primary contact recreation and domestic water supply). The numeric water quality criteria for

this designated use are an instantaneous maximum temperature of 22 °C with a maximum daily average temperature of no greater than 19 °C (IDAPA 58.01.02.250.02.b).

Different temperature criteria apply to lakes and reservoirs. A reservoir is considered a lake for the purpose of temperature criteria if its mean detention time is greater than 15 days (IDAPA 58.01.02.250.02.c). Detention time is defined in the Idaho Water Quality Standards as the mean annual storage volume divided by the mean annual flow out of the reservoir for the same period (IDAPA 58.01.2.060.01.h.iv). Using the mean annual flow measured downstream from the Lower Granite Dam, at USGS station number 13343600, for a low flow year (42,380 CFS, during water year 1979)¹ and the full pool storage of the reservoir (483,800 acre-feet),² the detention time of Lower Granite Pool is 5.8 days. Thus, Lower Granite Pool is not considered a “reservoir” for the purpose of applying water quality criteria for temperature.

In addition, a numeric criterion for “induced variation” in the ambient water temperature is applicable to this discharge. This criterion has been removed from the Idaho Water Quality Standards, but remains in effect for Clean Water Act purposes.³ This criterion requires that wastewater must not affect the receiving water outside the mixing zone so that the temperature is increased by more than 1 °C.

3.1.2 Natural Background

If the numeric temperature criteria are exceeded upstream of the discharge due to natural background temperatures, then wastewater must not raise the receiving water temperatures by more than 0.3 °C (58.01.02.200.09, IDAPA 58.01.02.401.01.c). As explained in Section 2.1.2 above, the natural background temperature of the Snake River exceeds Idaho’s numeric criteria in July, August, and September.

3.1.3 Mixing Zone Policy

A number of provisions of Idaho’s mixing zone policy (IDAPA 58.01.02.060) are potentially applicable to Clearwater Paper’s discharge, including:

- Mixing zones, individually or in combination with other mixing zones, shall not cause unreasonable interference with, or danger to, beneficial uses. Unreasonable interference with, or danger to, beneficial uses includes, but is not limited to, the following:
 - Impairment to the integrity of the aquatic community, including interfering with successful spawning, egg incubation, rearing, or passage of aquatic life.
 - Heat in the discharge that causes thermal shock, lethality, or loss of cold water refugia.
 - Lethality to aquatic life passing through the mixing zone.

¹ http://waterdata.usgs.gov/wa/nwis/annual/?search_site_no=13343600&agency_cd=USGS&referred_module=s&format=sites_selection_links

² <http://www.nww.usace.army.mil/Locations/DistrictLocksandDams/LowerGraniteLockandDam.aspx>

³ <http://www.deq.idaho.gov/epa-actions-on-proposed-standards>

- The width of a mixing zone is not to exceed twenty-five percent (25%) of the stream width.
- The mixing zone shall not include more than twenty-five percent (25%) of the low flow design discharge conditions as set forth in Subsection 210.03.b. of these rules.

Similar to temperature criteria, different mixing zone restrictions apply in lakes and in reservoirs with a mean detention time greater than 15 days (IDAPA 58.01.02.060.h.ii and iii). As explained in Section 3.1.1, Lower Granite Pool does not have a mean detention time greater than 15 days. Therefore, it is not considered a reservoir for the purpose of Idaho's mixing zone policy (IDAPA 58.01.2.060.01.h.iv).

The EPA believes that meeting the EPA's thermal plume recommendations, described in Section 4 below, will ensure that the mixing zone for temperature will not cause unreasonable interference with or danger to beneficial uses. These thermal plume recommendations are specifically designed to minimize or avoid lethality, thermal shock, and migration blockage to salmonids.

3.2 Washington

Because the discharge is close to waters of the State of Washington, the EPA has also considered Washington's water quality standards when evaluating the effect of the Clearwater Paper discharge. In Washington, the Snake River below the Clearwater River has the following temperature criteria: Temperature shall not exceed a 1-DMax of 20.0 °C due to human activities. When natural conditions exceed a 1-DMax of 20.0 °C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3 °C; nor shall such temperature increases, at any time, exceed $t = 34 / (T + 9)$.

The capital "T" in the equation above represents the background temperature.

The 1-DMax temperature is defined as "the highest water temperature reached on any given day. This measure can be obtained using calibrated maximum/minimum thermometers or continuous monitoring probes having sampling intervals of thirty minutes or less." Since this is the highest temperature reached on any given day, as opposed to the average temperature over the course of a day, it is analogous to (and more stringent than) Idaho's instantaneous maximum temperature criterion of 22 °C.

4 EPA Thermal Plume Recommendations

Although they are not water quality standards, the EPA also evaluated the Clearwater Paper discharge for consistency with the EPA's recommendations to avoid or minimize impacts of thermal discharges to salmonids. As explained above, the EPA believes that ensuring that the thermal plume meets these recommendations will also ensure that the mixing zone for temperature will not cause unreasonable interference with beneficial uses, consistent with Idaho's mixing zone policy. These are:

- Exposures of less than 10 seconds can cause instantaneous lethality at 32 °C (WDOE, 2002). Therefore, EPA suggests that the maximum temperature within the plume after 2 seconds of plume travel from the point of discharge does not exceed 32 °C.
- Thermal shock leading to increased predation can occur when salmon and trout exposed to near optimal temperatures (e.g., 15 °C) experience a sudden temperature increase to 26 – 30 °C for a short period of time. Therefore, EPA suggests that thermal plumes be conditioned to limit the cross-sectional area of a river that exceeds 25 °C to a small percent of the river (e.g., 5 percent or less).
- Adult migration blockage conditions can occur at 21 °C (Table 1). Therefore, EPA suggests that the cross-sectional area of a river at or above 21 °C be limited to less than 25% or, if upstream temperature exceeds 21 °C, the thermal plume be limited such that 75% of the cross-sectional area of the river has less than a de minimis (e.g., 0.25 °C) temperature increase.

The EPA also recommends that the thermal plume be limited so that temperatures exceeding 13°C do not occur in the vicinity of active spawning and egg incubation areas, or that the plume does not cause more than a de minimis (e.g., 0.25 °C) increase in the river temperature in these areas.

The receiving waters are not designated for salmonid spawning in Idaho, and the EPA has no information demonstrating that salmonid spawning is an existing use. Therefore, the EPA has not evaluated the discharge for consistency with this recommendation.

5 Temperature Effluent Limits in 2005 Permit

Since effluent limits are already in effect for the Clearwater Paper discharge, EPA must determine if the current limits are stringent enough to meet the water quality criteria, mixing zone requirements, and thermal plume recommendations described in Sections 3 and 4 of this document. To accomplish this, in general, EPA has assumed that the maximum effluent temperature is equal to the current temperature effluent limit. If a discharge at the current temperature limit would meet all mixing zone requirements, more stringent limits are not necessary, but the current effluent limits would be retained based on the anti-backsliding provisions of the Clean Water Act.

The temperature limits in the 2005 permit are:

- 33 °C from October – June
- 32 °C in July
- 31 °C in August and September

The temperature limits are expressed as maximum daily limits, which is defined as the maximum allowable average temperature over a calendar day. Thus, the temperature effluent limits in the 2005 permit have the same averaging period as the State of Idaho's maximum

daily average criterion of 19 °C (i.e., 1 day). Thus, the EPA has evaluated the effluent limits for compliance with this criterion, instead of the 22 °C instantaneous maximum criterion.

6 Cormix Modeling

The EPA used the Cormix model to determine whether a discharge at the limits in the 2005 permit would meet Idaho water quality standards at the edge of a mixing zone complying with Idaho's mixing zone policy and also meet the EPA's thermal plume recommendations described in Sections 3 and 4. Cormix is a comprehensive software system for the analysis, prediction, and design of outfall mixing zones resulting from discharge of aqueous pollutants into diverse water bodies.

The analysis was generally performed on a monthly basis, in order to capture variability in effluent limits and ambient temperatures (including ambient temperature stratification) throughout the year. At least one model simulation was set up for each month. Multiple simulations were set up for through October, to reflect different ambient temperature stratification conditions that have been observed during July and September and to investigate the effect of changes in effluent temperature (and therefore density) upon plume behavior in a stratified ambient density field during these months.

The simulations were repeated with different regulatory mixing zone specifications, in order to evaluate whether the plume would meet all of the requirements and recommendations in Sections 3 and 4.

6.1 Model Inputs

The Cormix model inputs and their bases are described below.

6.1.1 Effluent Tab

The effluent flow rate was set at 38 million gallons per day, which is the maximum daily effluent flow rate reported by the facility between May 2005 and February 2016.

The effluent temperature was used to specify the effluent density. In general, the effluent temperature was set equal to the applicable temperature limit for the month (see Section 5, above).

For scenarios in which the ambient temperature is vertically stratified (late July – October), the EPA also ran Cormix scenarios with the effluent temperature set equal to the average temperature reported for the month. Specifying a lower ambient temperature increases the reldensity of the discharge and can change the way the plume interacts with a stratified ambient density field. These average effluent temperatures were:

- 29.0 °C in July
- 28.0 °C in August
- 26.7 °C in September
- 25.8 °C in October.

With the exception of August, specifying the average effluent temperature instead of the effluent temperature limit there caused no significant differences in the plume's behavior. As described in Section 6.1.2.1, below, the plume behavior in August is sensitive to the effluent temperature.

The "Heated Discharge" pollutant type was selected. In addition to specifying the effluent temperature as an absolute value to quantify the effluent density, the discharge temperature is separately specified as an "excess" above the background temperature (i.e., the difference between the effluent and background temperature). This is straightforward at times when the ambient temperature is not stratified. Because the plume is positively buoyant and, when the effluent temperature is set equal to the effluent limit, the Cormix model predicts that the plume will quickly rise to the surface of the river year round, the "excess" temperature was calculated based on the (warmer) surface ambient temperature when vertical temperature stratification is observed (mid-July – October). A heat loss coefficient was specified for each month, based on Table 4.1 in the Cormix user manual (Doneker and Jirka 2014). Cormix uses this input to simulate heat dissipation to the atmosphere, for plumes that reach the surface of the water (as Clearwater Paper's plume does).

If the actual background temperature exceeded the target temperature (i.e., the 19 °C numeric water quality criterion for Idaho, the 20 °C numeric water quality criterion for Washington, or the 21 °C threshold for adult migration blockage), the discharge temperature was specified as an excess above the target instead of an excess above the actual (warmer) ambient temperature. This is a conservative approach that takes into account the uncertainty in the natural background temperature estimates. When the background temperature exceeds the numeric target, the target becomes an increase above the background temperature (0.25 – 0.3 °C). Specifying the discharge temperature as an excess above the target, as opposed to a smaller excess above the actual ambient temperature, will result in a larger predicted temperature increase in the receiving water.

6.1.2 Ambient Tab

6.1.2.1 Ambient Width and Depth

The EPA schematized the river channel differently in this analysis relative to the 2005 Temperature Assessment.

In the 2005 Temperature Assessment, the EPA represented vertically stratified conditions, in which the colder Clearwater River plunges beneath the warmer Snake River, by specifying a river channel with a reduced width and depth, to represent only the "Clearwater" layer of the river, thus excluding the upper ("Snake") layer of the river from the model. The EPA represented horizontally stratified conditions, in which the two rivers flow parallel to each other for several miles, by specifying the width of the river as the width of the Snake River upstream from the discharge.

In the revised analysis, the EPA specified the same width and depth for all simulations. The width and depth are consistent with cross section 139.22, located just downstream from the

discharge, as shown in *Appendix M: Results of Hydrology Studies: 1992 Reservoir Drawdown Test Lower Granite and Little Goose Dams* (USACE 1993). Both the average depth and the depth at the discharge were specified as 9.14 meters (30 feet). The river was represented as a bounded channel with a width of 610 meters (about 2000 feet).

In general, it is appropriate to use a cross-section located somewhat downstream from the discharge to schematize the river channel, because the Cormix model will account for any interactions with the stream bank or bottom, and these interactions will occur downstream from the point of discharge.

The Cormix model allows the user to specify a vertically stratified ambient density. Thus, the vertically stratified ambient density observed when the Clearwater River flow plunges below the Snake River flow can be represented directly in the model, without excluding the upper layer from the model. The model will then determine whether a positively buoyant plume (such as the plume created by the Clearwater Paper discharge) will “trap” at an intermediate depth at which it reaches a density equal to the ambient density, or break through the stratified ambient density field and reach the water surface.

In this analysis, in general, the Cormix model predicted that the positively buoyant discharge would reach the water surface after a short distance, even when the ambient temperature is stratified. Thus, it is more realistic to represent the entire river cross-section in the model, with a vertically stratified ambient density field than to exclude the upper layer of the river (consisting of warmer water from the Snake River), as was done in the 2005 Temperature Assessment.

The sole exception to this behavior was in the August simulation. In August, if the effluent temperature is set equal to the effluent temperature limit of 31 °C, the plume will break through the stratification and reach the surface within a short distance. However, if the effluent temperature is set equal to the average effluent temperature reported in August (28.0 °C), the plume will be confined to the lower layer of the river by the ambient stratification. This reduces the dilution that would occur at the boundary of a mixing zone encompassing 25% of the width of the river, relative to the scenario using 31 °C as the effluent temperature, in which the plume quickly reaches the surface. Specifically, in the effluent limit scenario, Cormix predicted that a dilution factor of 49.6 would be achieved at the boundary of a mixing zone encompassing 25% of the stream width. In the average effluent temperature scenario, the dilution factor at the boundary of a mixing zone encompassing 25% of the stream width was only 39.2.

However, the effect of this reduced mixing is offset by the reduced effluent temperature and the fact that the plume is interacting only with the cooler water below the pycnocline. Thus, the August simulation using the effluent temperature limit is the more critical condition, for temperature impacts (see Table 2, below).

Cormix does not have an option to specify a horizontally stratified ambient temperature, such as that which occurs when the two rivers flow parallel to each other downstream from the

confluence. However, the EPA believes it is more realistic to represent the entire cross-section of the river in the model, even during horizontally stratified conditions, instead of modeling the discharge as if the river is only as wide as the Snake River upstream from the discharge, as was done in the 2005 Temperature Assessment.

As explained in Sections 3 and 4, above, several of the mixing zone restrictions and thermal plume recommendations are specified as a percentage of the river's width or cross-sectional area. Thus, it is important to specify a realistic river cross-section so that the Cormix model can accurately determine the boundaries of a mixing zone specified as a percentage of the river's width or cross-sectional area and report the plume characteristics those locations.

In addition, the Cormix model accounts for plume interactions with the stream bank. When the Cormix model predicts that the plume has contacted the stream bank, it will abruptly shift the plume centerline to the contacted bank. The model will also assume that there is no more ambient water available for entrainment on the side of the plume which has contacted the bank, as the plume proceeds downstream, thus slowing mixing.

While, under some conditions, the Snake and Clearwater rivers flow side-by-side, with little mixing occurring between the two rivers' flows for several miles, the EPA does not believe it is realistic to represent the "boundary" between the two rivers' flows in the Cormix model as a stream bank, as was done in the 2005 Temperature Assessment, since it is not a solid physical boundary that will prevent entrainment of ambient water.

However, the EPA has nonetheless considered the potential for horizontal stratification of the Snake and Clearwater River flows when specifying the upstream temperature, as described below.

6.1.2.2 Temperature and Stratification

The EPA characterized the ambient density using temperature. The ambient temperatures specified in the model are always based on actual measurements, regardless of whether the ambient temperature exceeds the numeric water quality criteria, or whether the natural conditions water quality criteria are applicable. It is important to specify a realistic ambient temperature because Cormix uses the ambient temperature to calculate the ambient density, which is an important factor in determining the mixing properties of the discharge.

6.1.2.2.1 Late July – October: Vertical Stratification

From late July – October, the EPA estimated the vertically stratified ambient temperature profile from the chart of the observed temperature profile for the summer of 2003, at "Site 7," in Appendix A to *Hydraulic Characteristics of the Lower Snake River During Periods of Juvenile Fall Chinook Salmon Migration* (Cook et al. 2006). Site 7 was the closest ambient temperature monitoring location to the discharge. It was located about 268 meters downstream from the outfall, near the south bank of the Snake River, which is the bank nearer to the discharge location. From mid-July through the end of data collection in mid-October 2003, the ambient temperature was vertically stratified.

6.1.2.2.2 November – Early July: No Vertical Stratification

From November through early July, the EPA specified a uniform (unstratified) ambient temperature.

In early July, the temperature was estimated from the chart of the observed temperature profile for the summer of 2003, at “Site 7” in Appendix A to *Hydraulic Characteristics of the Lower Snake River During Periods of Juvenile Fall Chinook Salmon Migration*. The ambient temperature was not vertically stratified at this location in early July.

From November through June, the ambient temperature was based on USGS NWIS data for the Snake and Clearwater rivers, from USGS stations 13334300 and 13342500, respectively. During this time, the temperatures of the Snake and Clearwater rivers are similar, so no significant vertical temperature stratification will occur. However, horizontal stratification may occur.

As explained in Section 2.1, above, when the temperatures of the two rivers are similar, mixing properties at the confluence are determined by the relative flow rates of the two rivers.

When the flow rates of the two rivers are similar, water from the Snake and Clearwater Rivers flows in parallel, with little mixing occurring between the two rivers for several miles downstream of the confluence, and with water from the Clearwater River attached to the north bank and water from the Snake River attached to the south bank. Since the diffuser is located nearer to the south bank, near field mixing of the Clearwater Paper discharge will be primarily with water from the Snake River under these conditions. This mixing scenario is described in Section 4.2.1 of *Hydraulic Characteristics of the Lower Snake River During Periods of Juvenile Fall Chinook Salmon Migration*. This type of mixing was observed on April 4, 2002, when the ratio of the Clearwater River flow to the Snake River flow was 0.86 (i.e., the flow rate of the Clearwater River was 86% of the flow in the Snake River).

When the flow rates of the two rivers are dissimilar, the two rivers will mix relatively quickly near the confluence. Thus, under these conditions, near field mixing of the Clearwater Paper discharge will be with a mixture of water from the Snake and Clearwater Rivers. This mixing scenario is described in Section 4.2.2 of *Hydraulic Characteristics of the Lower Snake River During Periods of Juvenile Fall Chinook Salmon Migration*. This type of mixing was observed on May 24, 2003, when the ratio of the Clearwater River flow to the Snake River flow was 0.65.

A threshold flow ratio at which mixing properties change between these two types has not been identified. However, the EPA believes it is reasonable to assume, based on the examples described above, that, if the ratio of the Clearwater River flow to the Snake River flow is 0.65 or lower (i.e., the flow of the Clearwater River is less than or equal to 65% of the flow of the Snake River), the two rivers will mix at the confluence, since this mixing behavior has been observed at this flow ratio. If the ratio of the Clearwater River flow to the Snake River flow is greater than 0.65, then the EPA has assumed that the two rivers will flow parallel to each other for a significant distance downstream.

The EPA has therefore estimated the upstream temperature at the Clearwater Paper outfall from November – June as follows.

If the ratio of the Clearwater River flow to the Snake River flow is 0.65 or lower, the EPA has calculated the upstream temperature as the mixture of the temperatures of the Snake and Clearwater rivers. That is to say, the EPA has assumed that the two rivers mix immediately at the confluence under these conditions.

If the ratio of the Clearwater River flow to the Snake River flow is greater than 0.65, then the EPA has assumed that the upstream temperature is the temperature of the Snake River (with no influence from the Clearwater River). That is to say, the EPA has assumed that no significant mixing of the two rivers will occur near the outfall under these conditions.

The EPA estimated an upstream temperature as described above for each day for which both flow and temperature data were available from USGS NWIS for both rivers, from January 1, 2000 through September 30, 2015. The EPA then calculated the 90th percentile of these estimated temperatures for each month, and used those monthly 90th percentile values as the upstream temperature, from November – June.

The EPA believes this is a reasonable (although idealized) characterization of the ambient temperatures (and, in turn, densities) for this period of time.

6.1.2.3 Ambient Velocity

The EPA specified the monthly 7-day, 10-year low flow (7Q10) as the flow rate; the velocity was automatically calculated from the flow rate and the area of the schematized river cross section. The 7Q10 flow rates were calculated from the sum of the flow rates of the Snake and Clearwater Rivers, from USGS stations 13334300 and 13342500, respectively. The monthly 7Q10 flow rates and calculated velocities are listed in Table 1, below.

Clearwater Paper measured ambient velocity as a condition of its permit, from July – October during 2005 and 2006. The average velocities measured at station LGP-13, which is just downstream from the discharge, were 0.16 ft/s in 2005 and 0.33 ft/s in 2006 (AMEC 2006 and 2007). The calculated velocities for July – October are similar to the velocities measured in 2005 and 2006.

Table 1: 7Q10 Flow Rates and Calculated Ambient Velocities

Month	7Q10 (CFS)	Calculated Ambient Velocity (ft/s)
January	18,100	0.302
February	19,700	0.328
March	22,400	0.373
April	34,800	0.580
May	54,100	0.902
June	34,400	0.573
July	26,600	0.433

Month	7Q10 (CFS)	Calculated Ambient Velocity (ft/s)
August	19,800	0.330
September	16,200	0.270
October	15,500	0.258
November	16,400	0.273
December	15,700	0.261

6.1.2.4 Wind Speed

The wind speed was specified as 2 meters per second (4.5 miles per hour). This is the value recommended by the Cormix user manual as a conservative estimate, when field data are not available (Doneker and Jirka 2014).

6.1.2.5 Roughness

The EPA specified a Manning's "n" of 0.025 because it is the appropriate factor to use for an earthen channel with some stones and weeds, according to Table 4.3 of the Cormix user manual (Doneker and Jirka 2014).

6.1.3 Discharge Tab

The EPA selected the "CORMIX2" option because Clearwater Paper's effluent is discharged through a multiport diffuser.

The nearest bank is on the left, from the perspective of an observer looking downstream (i.e., the southern shore of the Snake River in Clarkston, WA). The EPA estimates that the near end of the diffuser is 183 meters from the bank, and the far end is 274 meters from the bank.

The diffuser length is the length from one diffuser end point (first nozzle/port) to the other endpoint (last nozzle/port). The Potlatch Mill diffuser length is 122 meters as reported in the 1997 Potlatch Mixing Zone Study and from Potlatch documents of the diffuser design.

The port height is the height of the discharge port centers above the bottom of the river. This value is 0.45 meters based on Potlatch diffuser design documents and the 1997 Potlatch Mixing Zone Study.

The port diameter is the average diameter of all ports/nozzles in this diffuser. This value is 0.0762 meters (3 inches) based on Potlatch diffuser design documents and the 1997 Potlatch Mixing Zone Study.

The contraction ratio is a coefficient that describes the shape of the port/nozzle. This can range from 1 for well-rounded ports to 0.6 for sharp-edged ports. A default value of 1.0 is used if the user does not know the actual contraction ratio. The value used for this discharge is 0.8 based on the 1997 Potlatch Mixing Zone Study.

The total number of openings is the total number of ports/nozzles for this diffuser. While the diffuser is designed with 80 ports, there are only 72 active ports based on a 1997 dive survey; therefore, EPA used 72 as the value in the model.

The alignment angle γ is the difference between the diffuser line and the ambient current measured counterclockwise from the ambient current direction. This value is 48 degrees based on aerial photos (Potlatch and IDEQ) and Potlatch diffuser design documents.

The nozzles per riser option allows the choice between 1) individual single ports (holes) or single nozzles attached to the diffuser, 2) two nozzles or ports per riser, or 3) several nozzles or ports per riser. Since the Potlatch diffuser has a single nozzle, EPA has chosen the “Single” nozzle per riser option. This was based on Potlatch diffuser design documents and the 1997 Potlatch Mixing Zone Study.

The “Orientation of Ports of Nozzles” option allows the choice between a unidirectional arrangement and an alternating arrangement. The unidirectional arrangement is where all the ports/nozzles point, more or less, into the same, mostly horizontal, direction. The alternating arrangement is where every other port/nozzle points into the opposite direction or all point directly upward in the vertical direction. Since the Potlatch diffuser nozzles are arranged so that they point in the same direction, EPA chose the “Unidirectional” nozzle arrangement option. This was based on Potlatch diffuser design documents and the 1997 Potlatch Mixing Zone Study.

The horizontal angle (σ) is the horizontal angle measured clockwise from the ambient current direction to the average port/nozzle centerline direction. Zero degrees represent all ports/nozzles pointing in the downstream direction in a co-flowing direction with the current and 90 degrees represents all ports/nozzles pointing perpendicular to, and to the left of, the ambient flow facing downstream in the current direction. This value is 318 degrees based on Potlatch diffuser design documents and the 1997 Potlatch Mixing Zone Study.

The relative orientation angle (β) is the nearest angle between the horizontal projection of the average port/nozzle centerline direction and the diffuser axis. Zero degrees represent all ports/nozzles oriented along the diffuser line (staged diffuser) and 90 degrees represents all ports/nozzles oriented normal to the diffuser line (unidirectional diffuser). This value is 90 degrees based on Potlatch diffuser design documents and the 1997 Potlatch Mixing Zone Study.

The nozzle direction option allows the choice between all ports/nozzles pointing in the same direction and the ports/nozzles arranged in a variable fanned-out orientation. EPA chose all nozzles pointing in the “same direction” option based on Potlatch diffuser design documents and the 1997 Potlatch Mixing Zone Study.

6.1.4 Mixing Zone Tab

The entries in the mixing zone tab vary based on the temperature target that was being evaluated against (i.e., the water quality criterion or the EPA thermal plume threshold temperature), the background temperature, and the mixing zone policy restriction or thermal plume recommendation.

For simulations that evaluate compliance with Idaho's water quality criteria and mixing zone policy, the mixing zone was specified as 25% of the channel width (IDAPA 58.01.02.060(h)(i)(1)).

For simulations that evaluate for consistency with the EPA's recommendation that the cross-sectional area of a river at or above 21 °C be limited to less than 25%, in order to prevent or minimize adult migration blockage, the mixing zone was specified as 25% of the channel area.

For simulations that evaluate for consistency with the EPA's recommendation that the cross-sectional area of a river at or above 25 °C be limited to less than 5%, in order to prevent or minimize thermal shock, the mixing zone was specified as 5% of the channel area.

For simulations that evaluate for consistency with the EPA's recommendation that the plume temperature drop to less than 32 °C within 2 seconds of plume travel in order to prevent instantaneous lethality, the mixing zone was specified a distance downstream. Cormix does not provide an option to specify a mixing zone in terms of plume travel time. Through trial-and-error, the EPA determined a downstream distance for each simulation, which is equivalent to 2 seconds of plume travel. This downstream distance is 1.1 – 1.46 meters.

For simulations that evaluate compliance with Washington's water quality criteria, the mixing zone was specified as a distance of 191 meters downstream from the discharge.

The water quality standard is specified as a non-toxic parameter, and the concentration is specified as an excess above background. For example, for January, when the background temperature is 4.4 °C, the water quality standard was specified as 14.6 °C when evaluating compliance with Idaho's water quality criterion of 19 °C.

6.2 Model Results

Model results are summarized in Table 2, below.

Table 2: Cormix Model Results

Month	Ambient T (°C)	Effluent T (°C)	T at 2 sec of Plume Travel (°C) Target: < 32 °C	T at 5% of Cross-Sectional Area (°C) Target: < 25 °C	T at 25% of Cross-Sectional Area (°C) Target: < 21 °C or < 0.25 °C increase	T at 25% of Stream Width (°C) Criterion: 19 °C and 1 °C increase or 0.3 °C increase	T at Washington Border (°C) Criterion: 20 °C and $t = 34 / (T + 9)$ increase ⁴ or 0.3 °C increase
January	4.4	33	8.1	5.8	4.7	5.0 (0.6 increase)	4.9 (0.5 increase)
February	4.8	33	8.4	6.2	5.1	5.4 (0.6 increase)	5.3 (0.5 increase)
March	7.9	33	10.9	9.1	8.2	8.4 (0.5 increase)	8.3 (0.4 increase)
April	11.1	33	13.3	11.9	11.2	11.4 (0.3 increase) ³	11.4 (0.3 increase)
May	13.2	33	14.7	13.7	13.3	13.4 (0.2 increase) ³	13.4 (0.2 increase)
June	18.3	33	19.8	18.8	18.4	18.5 (0.2 increase) ³	18.5 (0.2 increase)
Early July	20.0	32	21.4	20.5	20.1	0.21 increase	0.20 increase
Late July	22.5 ¹	32	23.6	22.9	0.096 increase	0.21 increase	0.20 increase
August (limit)	22.8 ¹	31	23.8	23.2	Note 2	0.24 increase	0.21 increase
August (avg.)	16.8 ⁵	28	18.4	17.5	Note 2	17.1 (0.3 increase)	17.1 (0.3 increase)

Month	Ambient T (°C)	Effluent T (°C)	T at 2 sec of Plume Travel (°C) Target: < 32 °C	T at 5% of Cross-Sectional Area (°C) Target: < 25 °C	T at 25% of Cross-Sectional Area (°C) Target: < 21 °C or < 0.25 °C increase	T at 25% of Stream Width (°C) Criterion: 19 °C and 1 °C increase or 0.3 °C increase	T at Washington Border (°C) Criterion: 20 °C and $t = 34 / (T + 9)$ increase ⁴ or 0.3 °C increase
Early Sep.	21.0 ¹	31	22.3	21.5	0.14 increase	0.25 increase	0.20 increase
Late Sep.	19.0 ¹	31	20.6	19.6	19.2	0.25 increase	19.2 (0.2 increase)
October	18.5 ¹	33	20.3	19.2	18.7	18.8 (0.3 increase)	18.8 (0.3 increase)
November	9.9	33	12.8	11.0	10.2	10.4 (0.5 increase)	10.3 (0.3 increase)
December	5.8	33	9.2	7.1	6.2	6.4 (0.6 increase)	6.3 (0.5 increase)

Notes:

1. The ambient temperature is stratified from late July – October. The ambient temperature listed is the temperature at the surface, because the plume is positively buoyant and will rise to the surface.
2. In both August scenarios, Cormix predicts that the plume will not spread such that the plume occupies 25% of the cross-sectional area of the river within 50,000 meters downstream of the discharge. However, in the effluent limit scenario, the temperature falls to 0.25 degrees above ambient 42.1 meters downstream from the discharge, and, in the average effluent temperature scenario, the temperature falls to 21 °C 0.2 meters downstream from the discharge. Thus, the discharge meets the thermal plume recommendation for migration blockage in August.
3. During April, May, and June, a mixing zone encompassing 25% of the stream width would extend downstream past the Washington border. The State of Idaho cannot authorize a mixing zone that extends into another State. Thus, the conditions at the Washington border (191 meters downstream) are reported.
4. The values of $t = 34 / (T + 9)$ are: 2.5 °C in January, 2.5 °C in February, 2.0 °C in March, 1.7 °C in April, 1.5 °C in May, 1.2 °C in June, 1.2 °C in late September, 1.3 °C in October, 1.8 °C in November, and 2.3 °C in December. From July – early September, the allowable temperature increase is 0.3 °C.
5. In the August scenario simulating a discharge at the average effluent temperature, the plume traps at an intermediate depth. For this scenario, the ambient temperature is listed as the temperature at the lower end of the pycnocline.

As shown in Table 2, above, the effluent limits in the 2005 permit satisfy all of the applicable water quality criteria and mixing zone restrictions as well as the EPA's recommendations for thermal plumes.

- The temperature after 2 seconds of plume travel is always less than 32 °C, with a maximum of 23.8 °C predicted in the effluent limit scenario for August, thus ensuring that the plume will not cause instantaneous lethality to salmonids.
- Less than 5% of the river's cross-sectional area will exceed 25 °C.
- Less than 25% of the river's cross-sectional will exceed 21 °C, or, if the upstream temperature exceeds 21 °C, less than 25% of the cross-sectional area of the river will experience a 0.25 °C temperature increase.
- The temperature meets Idaho's numeric water quality criteria for temperature or the 0.3 °C allowable increase above natural background, as applicable, at the edge of a mixing zone encompassing 25% of the stream width, or at the Washington border (whichever is more restrictive). These restrictions always result in less dilution (i.e., they are more stringent) than a mixing zone encompassing 25% of the volume of the 7Q10 flow rate (IDAPA 58.01.02.060.01.h.i.2).
- The discharge never increases the temperature of the river by more than 1 °C at the edge of a mixing zone encompassing 25% of the stream width, or at the Washington border (whichever is more restrictive). The maximum increase is 0.6 °C.

- The temperature meets Washington numeric water quality criteria for temperature or the 0.3 °C allowable increase above natural background, as applicable, at the Washington border.
- Because the plume generally rises quickly to the surface, the discharge will have an insignificant effect upon cold water refugia created by cool water from the Clearwater River, which will plunge to the bottom of the river channel.

7 References

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